

Climate and Decreasing Levels of Sulphate Aerosols in the High Arctic

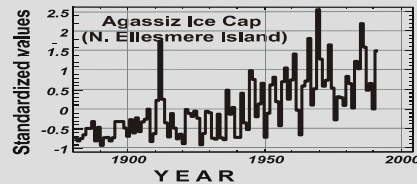
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Reducing Canada's vulnerability to climate change

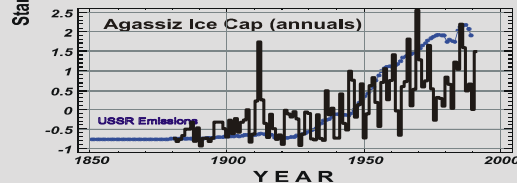
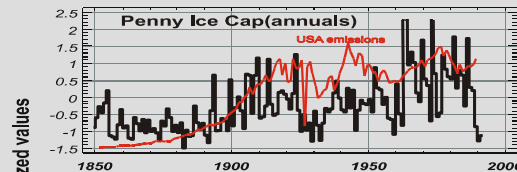
In the process of looking for a chemical signature to date an ice core, from N. Ellesmere I, Koerner & Fisher (1982) found that ions began to increase in concentration in snow layers deposited in the middle of the last century.

Because the analysis was restricted to liquid conductivity, the ions causing the increase remained unknown.

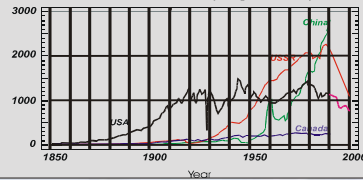


Late ion analysis showed that the increases are of the nitrate (NO₃⁻) and sulphate (SO₄²⁻) ions; the chloride ion (Cl⁻) exhibited no significant change over the same period. It was therefore concluded that the increases in both SO₄²⁻ and NO₃⁻ were of their pollutant precursors.

Further to the south, on Penny Ice Cap, Goto-Azuma & Koerner (2001) found the same ions began to increase earlier, at the beginning of the last century. By comparing these trends with those of sulphur dioxide (SO₂) emissions from Eurasia & North America they apportioned the pollutant ions on N. Ellesmere I. to Eurasia and those on Penny Ice Cap to N. America.

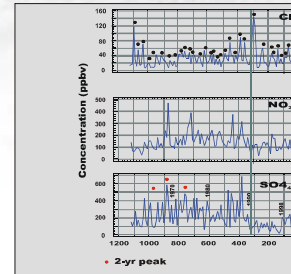


SO₂ Emissions (Megan tonnes)



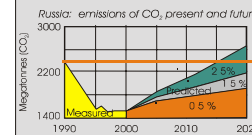
Global emissions show gradual increases in emissions up to 1990. Since then emissions in the USA, Canada (?) and Russia (especially) have dropped.

The question is: can these changes be picked up in the snows of the high Arctic?



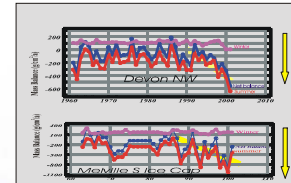
To update these records, samples from an 11 m pit and a 6 m ice core on Agassiz Ice Cap (N. Ellesmere Island) were collected in April 2003. The pit was dug at the top of the ice cap (1730 m asl) and the core was drilled 1.5 km downslope (1670 m asl). We show the pit records to the left.

Cl⁻ again shows no change, but there is a sharp increase in levels of the two pollutant aerosols beginning in the early 1990's. The timing of the pollutant aerosol decrease is close to that of the collapse of the Russian economy.



The diagram on the left illustrates CO₂ emissions where future values are based on a 0.5, 1.5 and 2.5% increase in energy consumption. Sulphate emissions might be expected to be similar.

A valuable **OUTPUT** of our work is that we will be able to give a good estimate of Russian emissions in the future as their economy revives. At present, estimates published in the Russian literature do not take account of the (alleged) number of leaks in their energy-transporting systems. If Kyoto ever takes off, believable emission figures are essential.



Our Arctic glacier monitoring programme has shown increased summer melting since the mid-1980's (downward yellow line in Figure to the left). Because sulphate aerosols have been shown to have a cooling effect on climate their reduced concentrations in the atmosphere might be expected to be the reason for this increased melting. However, maximum influx of sulphate aerosols is in late winter (see peaks in figures) when solar radiation is close to its minimum. We therefore attribute the increased melt to continually increasing levels of Greenhouse gases.

The next steps are to:

- 1: repeat the Agassiz work for reproducibility
- 2: Update the snow chemistry of older sites (Penny & Devlon Ice Caps), where emissions are from N. America.
- 3: Update and validate the emissions data for China, Russia and Canada.

References:

Koerner R.M. & D.A. Fisher. 1982. Acid snow in the Canadian High Arctic. *Nature*, 295, 137-140.
 Goto-Azuma, K., & R.M. Koerner. 2001. Ice core studies of anthropogenic sulfate and nitrate trends in the Arctic. *J. Geophys. Res.*, 106 (D5), 4959-4969.